



## **CSS Long Term Control Plan Update**

# **CSO Control Technology Screening**

**City of Alexandria  
Department of Transportation and Environmental Services**

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**GREELEY AND HANSEN**

## CSO Control Technology Screening

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## CSO Control Technology Screening

### Executive Summary

## Executive Summary

The City is currently in the process of updating its combined sewer overflow (CSO) long term control plan (LTCP), as required by the City's CSO permit from the Virginia Department of Environmental Quality (VDEQ). As part of the Long Term Control Plan Update (LTCPU), the City is performing a technology screening to identify suitable CSO control technologies for further evaluation. The purpose of the screening is to perform a high level evaluation of a wide variety of CSO control technologies and select the technologies that have the greatest potential for meeting the City's water quality and CSO control goals for a more in-depth evaluation.

The City's water quality goals are driven by a number of regulatory requirements, including the requirements of its CSO permit and the Hunting Creek Bacteria TMDL, which impacts CSO outfalls 002, 003 and 004. As such, the technologies considered in this memorandum were evaluated for their ability to meet the following primary goals: 1) bacteria reduction; 2) CSO volume reduction. Although not explicitly required by the Hunting Creek Bacteria TMDL, the following secondary goals are also considered for the various technologies: 1) biochemical oxygen demand (BOD) reduction / dissolved oxygen (DO) enhancement; 2) TSS reduction; 3) floatables reduction; 4) ancillary environmental / public benefit.

Based upon the screening of technologies presented in this memorandum, the following technologies have been identified as primary technologies for detailed consideration as part of the alternatives evaluation:

- Separation
- Conveyance
- Outfall Consolidation/Relocation
- Tunnel Storage
- Tank Storage
- Disinfection
- Green Infrastructure (GI)

Additionally, the following technologies have been identified as complementary technologies that may play important, but smaller roles in the City's LTCPU:

- Roof Leader Disconnection
- Sump Pump Disconnection
- Regulator Modifications
- Real Time Control

## CSO Control Technology Screening

### Executive Summary

Based on this screening technical memorandum, Table ES-1 summarizes the alternatives and associated technologies that are recommended for the more detailed evaluation in the Alternatives Evaluation phase. Additional combinations may be considered as the detailed evaluations progress.

**Table ES-1**  
**Summary of Alternatives**

No.	Description	Technologies
1.	Tunnels from CSO 003/004 and CSO 002 to AlexRenew	Storage, Outfall Consolidation, Regulator Modifications, and Real Time Control
2.	Tunnel to the Potomac River capturing CSO 002, 003, and 004.	Storage, Conveyance, Outfall Relocation, Regulator Modifications, and Real Time Control
3.	Storage at CSO 003/004 and CSO 002	Above Ground Storage, Below Ground Storage, and Regulator Modifications
4.	Disinfection	UV, Peracetic Acid, and Sodium Hypochlorite Disinfection
5.	Separation	Rain Leader Disconnection, Sump Pump Disconnection, Sewer Separation
6.	Green Infrastructure	Permeable Pavement, Planter Boxes, Bioswales, and Rain Gardens
7.	Tunnel from 003/004 to AlexRenew + Storage at 002	Storage, Outfall Consolidation, Regulator Modifications, and Real Time Control
8.	Tunnel form 003/004 to AlexRenew + Disinfection at 002	Storage, Outfall Consolidation, Regulator Modifications, Disinfection, and Real Time Control
9.	Tunnels from 003/004 and 002 + GI and Separation	Storage, Outfall Consolidation, Regulator Modifications, GI, and Separation, and Real Time Control
10.	Tunnel from 003/004 to AlexRenew + Storage at 002 + GI and Separation	Storage, Outfall Consolidation, Regulator Modifications, GI, and Separation, and Real Time Control

## CSO Control Technology Screening

### Section 1

## Section 1 Introduction

The purpose of this memorandum is to review a wide variety of combined sewer overflow (CSO) control technologies and screen them in order to identify a handful of select technologies that have the greatest potential to meet the City's water quality and CSO control goals. This screening is limited to the consideration of the capabilities of different CSO control technologies in general, and is not intended to evaluate site-specific implementation of technologies. Based upon the findings of this screening, several technologies have been recommended for further consideration as part of the alternatives evaluation phase of the CSO long term control plan update (LTCPU).

The technologies considered in this memorandum have been evaluated for their effectiveness in meeting the following primary water quality and CSO control goals to meet the Hunting Creek TMDL and CSO Policy:

- Bacteria reduction
- CSO volume reduction

Although not explicitly required by the Hunting Creek TMDL, the following secondary goals were considered:

- Biochemical oxygen demand (BOD) reduction / Dissolved oxygen (DO) enhancement
- Total suspended solids (TSS) reduction
- Floatables reduction
- Ancillary environmental / public benefits

Each of the CSO control technologies considered in this memorandum has been assigned to 1 of 5 program role categories, based upon the ability of the technology to meet the goals listed above. The program role categories are an indication how a given technology could fit into the overall program plan of the LTCPU. Descriptions of the program role categories are provided below:

- Primary Technology – Key technologies that are highly capable of meeting water quality and CSO control goals;
- Complementary Technology – Suitable technologies that can have positive impacts, but are somewhat limited in effectiveness;
- Program Enhancement – Technologies that are generally good practices, but will likely have little impact on water quality and CSO control goals;
- In place/In-progress – Technologies that are already being implemented by the City or have near-term plans for implementation; and
- Not Recommended – Technologies that has been removed from consideration for various reasons (cost, maintenance, public acceptance, etc.).

## CSO Control Technology Screening

### Section 1

The City's VPDES Permit indicates, "the permittee shall develop a Long Term Control Plan Update (LTCPU), consistent with the September 1995 EPA Guidance for LTCP...". The EPA guidance document identifies the following four categories of control technologies that should be considered during a screening:

- Source Control;
- Collection System Control;
- Storage Technologies; and
- Treatment Technologies.

Table 1-1, Table 1-2, and Table 1-3 on the following pages provide a summary of all the technologies considered in this memorandum. Sections 2 through 5 provide a more detailed description of each of the considered technologies, as well as the benefits and concerns associated with the technologies. Section 6 provides an in-depth evaluation of different types of green infrastructure technologies that could be implemented in the City.

The City has identified green infrastructure (GI) as a technology that will likely play a key role in the LTCPU because of the ancillary environmental and public benefits that it provides. GI is being used as a primary CSO control approach in other LTCP programs, including the City of Philadelphia and New York City. GI will be evaluated as a standalone primary alternative; however, since standalone GI technologies are not anticipated to meet the bacteria reductions required by the City's CSO permit and Hunting Creek TMDL, GI will also be evaluated in conjunction with other primary alternatives. Since GI will play a unique role in the LTCPU, it is discussed in detail in its own section (Section 6).

**Table 1-1  
Technology Screening Summary – Source Control**

Technology Group	Practice	Primary Goals		Secondary Goals				Implementation & Operation Factors	Program Role	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction	BOD Reduction	TSS Reduction	Floatables Reduction	Ancillary Environmental			
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	Low	Low	High	None	Limited by potential for flooding (freezing potential); Low operational cost; Helps restore creek base flow.	Not Recommended	No
	Catch Basin Modification (for floatables control)	Low	None	Low	Low	High	Low	Requires suitable catch basin configuration; Potential for clogging/flooding if regular maintenance is not performed.	Program Enhancement	No
	Green Infrastructure <sup>(1)</sup>	Medium	Medium	Medium	Medium	Medium	High	Site specific, many sites are needed to create meaningful storage; becomes cost-effective when implemented with redevelopment. Suggest starting with pilot or demonstration projects before full scale implementation. High capital and moderate O&M cost; Helps restore creek base flow.	Primary Technology	Yes
Public Education & Outreach	Water Conservation	Low	Low	Low	Low	Low	High	Coordinate with Water Company; Low overall cost. Saves on water supply infrastructure needs.	Program Enhancement	No
	Catch Basin Stenciling	Low	None	Low	None	High	High	Inexpensive; Easy to implement; Public education potential; Helps reduce pet waste & car washing.	Program Enhancement	No
	Community Cleanup Programs	None	None	None	None	High	High	Inexpensive; Sense of community spirit; Educational BMP; Aesthetic enhancement.	In place/In-Progress	No
	Public Education Programs	Low	None	Low	None	High	High	Increased City commitment; Low overall cost; Helps reduce pet waste & car washing.	In place/In-Progress	No
	FOG Program	None	None	None	None	None	High	Increased City commitment; Reduces DWO/SSO risk & sewer backups.	Program Enhancement	No
	Garbage Disposal Restriction	None	None	None	Low	None	None	Requires increased allocation of resources to enforce: Will likely face strong public opposition.	Not Recommended	No
	Pet Waste Management	Medium	None	Medium	Low	None	High	Site specific; low cost, long term program; TMDL indicates that roughly 25% of in-stream bacteria is attributed to pet waste.	In place/In-Progress	No
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	None	High	Medium	Medium	Increased City enforcement efforts; Contractor/Owner responsible for compliance.	In place/In-Progress	No
	Illegal Dumping Control	None	None	Low	Low	High	High	Enforcement of current law requires large number of code enforcement personnel; Recycling sites maintained.	In place/In-Progress	No
	Pet Waste Control	Medium	None	Medium	Low	None	High	Site specific; low cost, long term program; TMDL indicates that roughly 25% of in-stream bacteria is attributed to pet waste.	In place/In-Progress	No
	Litter Control	None	None	None	None	High	High	Aesthetic enhancement; Labor intensive.	In place/In-Progress	No
	Illicit Connection Control	Low	None	Low	Low	Low	High	Site specific; Interaction with home owners required.	In place/In-Progress	No
Good Housekeeping	Street Sweeping / Flushing	Low	None	Low	High	High	High	Labor intensive; Specialized equipment; Doesn't address flow or bacteria.	In place/In-Progress	No
	Leaf Collection	None	None	Low	None	High	High	Ongoing; Labor intensive; Long term program.	In place/In-Progress	No
	Recycling Programs	None	None	None	None	High	High	Ongoing City commitment.	In place/In-Progress	No

(1) Individual GI technologies are considered in greater detail in Section 6



Table 1-2  
Technology Screening Summary – Collection System Control

Technology Group	Practice	Primary Goals		Secondary Goals				Implementation & Operation Factors	Application Category	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction	BOD Reduction	TSS Reduction	Floatables Reduction	Ancillary Environmental			
O&M	I/I Reduction	Low	Medium	Low	Low	Low	High	Infiltration control may have minimal impact on CSO volume compared to inflow; Labor intensive; Requires specialized equipment; Particularly effective in separated sewer areas; Ongoing O&M. Reduced need for additional wastewater treatment capacity.	In place/In-Progress	No
	Advanced System Inspection & Maintenance	Low	Low	Low	Low	Low	Low	Inspection, removal of debris and increased flow to plant.	In place/In-Progress	No
	Combined Sewer Flushing	Low	Low	Low	High	High	Low	Maximizes existing collection system; Reduces first flush effect; Labor intensive.	Not Recommended	No
	Catch Basin Cleaning	Low	None	Low	High	High	Low	Labor intensive; requires specialized equipment.	In place/In-Progress	No
Combined Sewer Separation	Roof Leader Disconnection	Low	Medium	Low	Low	Low	Medium	Site specific; Interaction with home owners required; Helps restore creek base flow.	Complementary Technology	Yes
	Sump Pump Disconnection	Low	Low	Low	Low	Low	Medium	Site specific; Interaction with home owners required; Helps restore creek base flow; May reduce basement backups.	Complementary Technology	Yes
	Complete Separation	High	High	High	Low	Low	Low	Disruptive to affected areas, cost intensive, potential for increased stormwater pollutant loads, requires homeowner participation.	Primary Technology	Yes
Combined Sewer Optimization	Conveyance	High	High	High	High	High	Low	Disruptive to affected areas; potentially expensive in congested urban areas; aesthetically acceptable; provides storage and conveyance.	Primary Technology	Yes
	Regulator Modifications	Medium	Medium	Medium	Medium	Medium	Low	Relatively easy to implement with existing regulators; potential for increased O&M burden. Need to evaluate risk of upstream flooding. Low capital and moderate O&M cost.	Complementary Technology	Yes
	Outfall Consolidation/Relocation	High	High	High	High	High	Medium	Directs flow away from specific area; Low operational cost; May reduce permitting/monitoring; Can be used in conjunction with storage & treatment technologies; Can redirect flow to areas with more assimilation capacity.	Primary Technology	Yes
	Real Time Control	Medium	Medium	Medium	Medium	Medium	Medium	Highly automated system; Mechanical control requires O&M; Increases potential for sewer backups; May minimize public disruption.	Complementary Technology	Yes

**Table 1-3**  
**Technology Screening Summary – Storage & Treatment**

Technology Group	Practice	Primary Goals		Secondary Goals				Implementation & Operation Factors	Application Category	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction	BOD Reduction	TSS Reduction	Floatables Reduction	Ancillary Environmental			
Linear Storage	Pipeline	High	High	High	High	High	Medium	Require large diameter pipeline or long small diameter pipeline; Requires much less available land than point storage. Highly disruptive to public; Increased O&M costs.	Not Recommended	No
	Tunnel	High	High	High	High	High	Medium	Eliminates land restrictions and costs associated with storage basins; Tunnels can provide large storage volumes with relatively minimal disturbance to the ground surface which can be very beneficial in congested urban areas; Increased O&M costs.	Primary Technology	Yes
Point Storage	Tank	High	High	High	High	High	Low	Includes variations of retention; detention and flow-through systems; Requires large area for tank installation; Increased O&M costs; Potentially high neighborhood disturbance.	Primary Technology	Yes
	Wet Weather Storage Basin - Alex Renew WRRF	High	High	High	High	High	Medium	Primary function is nutrient load equalization (not wet weather storage); Unlikely to provide the storage volume needed by the City; Requires coordination and consensus building with Alex Renew.	In place/In-Progress	No
Treatment – CSO Facility	Vortex Separators	None	None	None	High	High	Low	Increased O&M costs; Space required; challenging controls for intermittent and highly variable wet weather flows; and pumping costs.	Not Recommended	No
	Screens	None	None	None	None	High	Low	Low capital cost; Mechanical device requires additional O&M.	Not Recommended	No
	Netting	None	None	None	None	High	Low	Low capital cost; Labor intensive; High O&M; Negative aesthetic impact.	Not Recommended	No
	Contaminant Booms	None	None	None	None	High	Low	Low capital cost; Labor intensive; High O&M; Negative aesthetic impact.	Not Recommended	No
	Baffles	None	None	None	None	High	Low	Low capital cost; Low O&M; Easy to install; Requires proper hydraulic configuration	Not Recommended	No
	Disinfection	High	None	None	None	None	Low	Disruptive to affected areas during construction; Increased O&M burden due to satellite facilities, transport and storage of chemicals, and pumping costs; High capital and O&M cost.	Primary Technology	Yes
	High Rate Physical/Chemical Treatment (ActiFlo ®)	None	None	High	High	High	Low	Requires large footprint; High O&M costs; limited ammonia removal.	Not Recommended	No
	High Rate Physical (Fuzzy Filters ®)	None	None	Medium	Medium	High	Low	Requires large footprint; Moderate O&M costs; Requires upstream grit removal and downstream disinfection.	Not Recommended	No
Treatment - WRRF	Additional Treatment Capacity - Alex Renew WRRF	High	High	High	High	High	Low	Very high capital costs; Requires coordination and consensus building with Alex Renew	Not Recommended	No
	Wet Weather Blending - Alex Renew WRRF	Low	High	Low	High	High	Low	High capital costs; Provides limited benefit compared to CSO facility disinfection; Requires coordination and consensus building with Alex Renew	Not Recommended	No

## CSO Control Technology Screening

### Section 2

## Section 2 Source Control

EPA defines source controls as those that impact the quality or quantity of water entering the combined sewer system (CSS). Source controls measures can reduce volumes, peak flows, or pollutant discharges that may decrease the need for more capital-intensive technologies downstream in the CSS. However, source controls typically require a high level of effort to implement on a scale that can achieve a measureable impact.

### 2.1 Stormwater Management

Stormwater management controls consist of measures designed to capture, treat, or delay stormwater prior to entering the CSS.

#### **Street/Parking Lot Storage (Catch Basin Control)**

This type of source control can be accomplished by modifying catch basins to restrict the rate of stormwater runoff that enters the CSS. A portion of the stormwater runoff that would otherwise immediately enter the CSS is allowed to pond on streets or parking lots for a period of time before entering the CSS. This control measure can be very effective at reducing peak flows during wet weather events, when most CSOs occur. However, this practice typically faces strong public opposition and can lead to hazardous road conditions if not managed properly (e.g. hydroplaning, ice formation during winter months, etc.). As such, these controls are not recommended for the City's LTPCU.

#### **Catch Basin Modification (for Floatables Control)**

Catch basin modifications consist of various devices to prevent floatables from entering the CSS. Inlet grates can reduce the amount of street litter and debris that enters the catch basin. Other modifications such as hoods, submerged outlets and vortex valves, alter the outlet pipe conditions and keep floatables from exiting the catch basin and continuing downstream. These devices also provide a water seal for containing sewer gas. The success of a catch basin modification program is dependent on having catch basins with sumps deep enough to install hood-type devices. Many of the City's catch basins already have hood devices. A potential disadvantage of catch basin outlet modifications and other insert-type devices is the fact that retained materials could clog the outlet if cleaning is not performed regularly.

The City has a catch basin cleaning program as required by the Nine Minimum Controls in its CSO permit. Since these modifications do not address the LTCPU's primary goals (bacteria and volume reduction), this technology is considered a program enhancement and will not be considered further in the alternatives evaluation.

#### **Green Infrastructure**

Green infrastructure (GI) has been identified as a technology that will be considered in the alternatives evaluation. GI technologies are discussed in detail in Section 6.

## **CSO Control Technology Screening**

### **Section 2**

## **2.2 Public Education & Outreach**

Public education and outreach is a non-structural control measure aimed at limiting the negative effects of certain human behavior on the CSS. Promoting certain human actions and discouraging others can impact the quality and quantity of water discharged to the CSS. The City has an ongoing and robust public education and outreach program that incorporates many of the practices discussed below. Additionally, the City's VPDES permit has several requirements for public notice and information.

### **Water Conservation**

Water conservation in CSS areas can reduce the volume of direct discharges to the system. This flow reduction could potentially benefit the Alexandria Renew Enterprises (AlexRenew), the receiving water resources reclamation facility (WRRF), by delaying the need for expansion to accommodate future flows. Water conservation measures include the installation of low-flow fixtures, education to reduce water waste, leak detection and correction, and other programs. Although this measure has the potential to decrease CSS flows and can have ancillary benefits for the WRRF, it has very little impact on peak flows, which cause most CSOs. As such, this technology is considered a program enhancement and will not be considered further in the alternatives evaluation.

### **Catch Basin Stenciling**

Stenciling consists of marking catch basins with symbols and text such as, "Drains to the Bay" or "Only Rain Down the Storm Drain". This measure can help increase public awareness of the sewer system and discourage the public from dumping trash into the CSS, which can cause blockages and lead to CSOs.

### **Community Cleanup Programs**

Community cleanup programs are an inexpensive and effective way to reduce floatables entering the CSS and provide educational benefits to the community. Cleanup activities can be organized by local businesses, non-profit organizations, and student chapters at all levels. It is a great way to raise the sense of community spirit and environmental awareness. Many community cleanup events are held across the City each year, such as Four Mile Run Park / Hume Springs Park Coastal Cleanup and the Oronoco Bay Park Coastal Cleanup. Due to the healthy amount of community cleanup programs that are currently being implemented in the City, this measure will not be considered further.

### **Public Education Programs**

Public education programs help raise citizens' awareness of water quality and other environmental issues. It encourages people to do their part to reduce toxic and floatable waste entering local waterways. The City is currently implementing several public education programs, such as "Only Rain Down the Storm Drain", participation in the City's annual Earth Day festival, and the Environmental Policy Commission (EPC). The City's education programs are considered to be implemented to a satisfactory level. As such, this measure will not be considered further.

## **CSO Control Technology Screening**

### **Section 2**

#### **FOG Program**

FOG buildup can clog sewer and drainage pipes, resulting in messy, costly sanitary sewer overflows. These overflows are bad for business, the environment and public health. FOG programs often consist of food service establishment inspection, installation of Grease Removal Devices (GRDs) and development of a preferred pumper program for proper maintenance of GRDs. However, FOG programs have little effect on the amount of bacteria in the collection system and do not provide any flow reductions. As such, this measure is considered to be a program enhancement and will not be considered further.

#### **Garbage Disposal Restrictions**

Garbage disposals provide a convenient means for residences and businesses to dispose of food waste. However the use of garbage disposals increases the amount of food scrap entering the sewer system, which may cause blockages and decrease the flow capacity in the CSS. Restricting garbage disposal usage has the potential to decrease the number of blockages that occur each year. Garbage disposal restrictions require an increased allocation of resources for enforcement and can face considerable public resistance. Furthermore, this practice does very little to reduce wet weather CSO events or decrease bacteria loads. As such, this technology is not recommended and has been removed from further consideration.

#### **Pet Waste Management**

In the Hunting Creek TMDL, roughly 25% of the in-stream bacteria load is attributed to pet waste. When pet waste is not properly disposed of, it can be carried away by stormwater runoff and washed into storm drains or nearby streams. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in waterways, causing significant water pollution. An effective pet waste management program can help increase public awareness and encourage proper waste disposal. This is a low cost, long term program that has the potential reduce bacteria loads to both the CSS and directly to local streams. The City already has a pet waste management education program in place. As such this measure will not be considered further.

### **2.3 Ordinance Enforcement**

#### **Construction Site Erosion & Sediment Control**

Construction site erosion and sediment (E&S) control involves management practices aimed at controlling the transport of sediment and silt by stormwater from disturbed land. E&S control has the potential to reduce sediment loads to both the CSS and directly to streams, and can help reduce sewer cleanout O&M costs. Given that the City already has an E&S control program in place and an extremely small amount of land in the CSS area is under construction at any given time, this alternative is considered to be implemented to a satisfactory level and will not be considered further.

#### **Illegal Dumping Control**

Illegal dumping is the disposal of trash or garbage by dumping, burying, scattering, or unloading trash in an unauthorized place, such as public or private property, streets or alleys, or directly into the CSS. When it occurs, illegal dumping contributes a considerable amount of floatables to stormwater runoff, as well as a moderate amount of bacteria, settleable solids, and other pollutants. Local ordinances can be used as

## CSO Control Technology Screening

### Section 2

needed to investigate complaints, determine if a violation exists, identify the responsible party, and follow up with the appropriate legal actions. This measure can be an effective tool in reducing stormwater floatables. Illegal dumping is outlawed by City ordinance. As such, this measure will not be considered further.

#### **Pet Waste Control**

As described in the previous section, pet waste can be a significant contributor of bacteria to stormwater. Public education and outreach programs can help raise public awareness and reduce the level of improper waste disposal. Additional gains can be made through enforcement of the pet waste ordinances, which can be an effective tool in achieving public compliance. The City has a pet waste ordinance (City Code §5-7-46) that is considered to be enforced at a satisfactory level. As such, this measure will not be considered further.

#### **Litter Control**

Litter consists of waste products that have been disposed of improperly in an inappropriate area. Litter is easily washed into the collection system during wet weather events, which increase the amount of floatables in the system. Strict enforcement of the litter control ordinances can help to curb violations and decrease the amount of floatables that make their way into the CSS. The City has a litter control ordinance (City Code §13-1-21.1) that is considered to be enforced at a satisfactory level. As such, this measure will not be considered further.

#### **Illicit Connection Control**

An illicit discharge is any discharge to the municipal separate storm sewer system (MS4) that is not composed entirely of storm water, except for discharges allowed under a NPDES permit or waters used for firefighting operations. Illicit connections can contribute polluted water, solids, and trash to the stormwater system, where it is eventually discharged to the environment without receiving proper treatment. These connections can be reduced through the implementation of an illicit discharge detection and elimination (IDDE) program. Although this measure does not directly target the CSS, it can have significant impacts on local water quality that can help to address TMDLs. The City has an IDDE program in place that is considered to be enforced at a satisfactory level. As such, this measure will not be considered further.

## 2.4 Good Housekeeping

#### **Street Sweeping / Flushing**

Municipal street cleaning enhances the aesthetic appearance of streets by periodically removing the surface accumulation of litter, debris, dust and dirt, which prevents these pollutants from entering storm or combined sewers. Common methods of street cleaning are manual, mechanical and vacuum sweepers, and street flushing. However, the total public area accessible to street sweepers is limited, and generally does not include sidewalks, traffic islands, and congested street parking areas. Although street sweeping/flushing can reduce the concentration of floatables and pollutants in storm runoff that originate from the street, the measure has minimal impact on bacteria or CSO volume reduction. The City has a street sweeping program in place, as required by the Nine Minimum Controls in its CSO permit. As such, this measure will not be considered further.



## **CSO Control Technology Screening**

### **Section 2**

#### **Leaf Collection**

Leaf collection is an important part of stormwater management because it not only keeps leaves out of the stormwater system to maintain its maximum flow capacity, but also benefits water quality by reducing nutrients such as phosphorous and nitrogen that can originate from the decomposition of leaves. In most municipalities, this long term stormwater management measure is scheduled based on seasonal patterns, and is an effective tool to maintain capacity in both the separate storm sewer and the CSS. The City has a leaf collection program in place, as required by the Nine Minimum Controls in its CSO permit. As such, this measure will not be considered further.

#### **Recycling Programs**

Recycling programs provide a means for the public to properly dispose of items that may otherwise end up entering the CSS, such as motor oil, anti-freeze, pesticides, animal waste, fertilizers, chemicals, and litter. These programs are usually effective in reducing floatables and toxins. The City currently manages a robust recycling program that is considered to be implemented at a satisfactory level. As such, this measure will not be considered further.

## CSO Control Technology Screening

### Section 3

## Section 3 Collection System Control

EPA defines collection system controls as measures that remove or divert stormwater runoff or maximize the capacity of the collection system. Collection system controls have no impact on water quality, but do have the potential to reduce the volume of CSO events.

### 3.1 Operations & Maintenance

#### Infiltration/Inflow Reduction

Infiltration and Inflow (I/I) can significantly limit the hydraulic capacity of a collection system, if not held in check. Inflow comes from sources such as roof drains, manhole covers, cross connections from storm sewers, catch basins, and surface runoff. Infiltration comes from groundwater that seeps in through leaking pipe joints, cracked pipes, manholes, and other similar sources. Identifying I/I sources is labor intensive and requires specialized equipment. Additionally, significant I/I reductions can be difficult and expensive to achieve. However the benefit of a good I/I control program is that it can save money by extending the life of the system, reducing the need for expansion, and lowering treatment costs.

I/I reduction for combined sewers provides limited gains, since water tends to find another way into the system. However, I/I reductions in sanitary sewers can have significant impacts on increasing the available capacity in the downstream CSS. The City has an I/I reduction program in place. The City has rehabilitated approximately 40 miles of sewer (both sanitary and combined) since the program's implementation. Additional funds are currently being allocated to continue the City's I/I reduction program. As such the program is considered to be appropriately in place and will not be considered further for the LTCPU.

#### System Inspection & Maintenance

System inspection and maintenance programs can provide valuable knowledge about the condition of the City's CSS infrastructure to help inform planning, inspection, and maintenance activities. This can help ensure design flow capacity can be consistently available to prevent CSO events. The City has an inspection and maintenance program in place that is considered to be implemented at a satisfactory level. As such, this measure will not be considered further.

#### Combined Sewer Flushing

This type of O&M practice re-suspends solids that have settled in the CSS and flushes them downstream to AlexRenew. This practice consists of introducing a controlled volume of water over a short duration at key points in the collection system using external water from a tank truck, pressurized feed, or by detaining the CSS flow for a period, and then releasing it. This practice helps reduce the amount of settled solids that are re-suspended and discharged during significant wet weather events. This measure is most effective when applied to flat collection systems since solids are more likely to become deposited on flat grades. The City has a combined sewer flushing program in place that is considered to be implemented as a satisfactory level. As such, it will not be considered further.



## CSO Control Technology Screening

### Section 3

#### **Catch Basin Cleaning**

Catch basin cleaning reduces the transport of solids and floatables to the CSS by regularly removing accumulated catch basin deposits. Methods to clean catch basins include manual, bucket, and vacuum removal. Catch basins cleaning can be effective in reducing floatables in combined sewer, however, it is not effective a bacteria reduction or volume reduction, nor is it particularly effective at BOD reduction. The City has a catch basin cleaning program in place that is considered to be implemented at a satisfactory level. As such, this measure will not be considered further.

### **3.2 Combined Sewer Separation**

#### **Roof Leader Disconnection**

Roof leaders may directly be connected to the CSS. Roof leaders can be disconnected in order to divert stormwater elsewhere and/or to delay its entry into the CSS. Depending on the neighborhood, roof leaders may be run to dry well, vegetation bed, lawn, storm sewer, or street. This technology typically has limited benefits in dense urban areas (such as the City's CSS area) due to the lack of pervious areas available to divert flow for infiltration. Unfortunately, the most feasible rain leader disconnection scheme in these areas is usually diversion to the street. In this case, disconnection can lead to nuisance street flooding and is only able to briefly delay the water from entering the CSS through catch basins.

Roof leader disconnection is typically much more effective in areas with separate sewers where the roof leader was previously connected to a sanitary sewer, since the diverted rainwater does not have a direct path back into the system. Roof leader disconnection can be effective for both sanitary and storm sewers; however, the effect of this measure is highly contingent upon the extent of roof leaders in the system, site specific conditions, and the ability to find an adequate location to divert stormwater flow from the roof leader. Since there are some limitations to the effectiveness of this technology, it is considered to be a complementary technology that will be considered under the GI category potentially coupled with other GI technologies (i.e. planter boxes, rain barrels, etc.), but will most likely not be a core component of the City's CSO control strategy.

#### **Sump Pump Disconnection**

Buildings with basements below the ground water table sometimes are kept dry by using dewatering pumps. In many cases, these pumps discharge to the CSS or sanitary sewers. Sump pump disconnection diverts this pumped groundwater flow to a location other than these sewers. Sump pump disconnection programs are typically more effective in separate sewer areas and are subject to the same limitations as roof leader disconnection programs (extent, site conditions, diversion options, etc.). There are many limitations to the effectiveness of this approach in terms of the cost, impact on the public and difficulties implementing. Additionally, the City does not have records on which properties have sump pumps connected to the CSS and which properties do not to determine the impact. This technology approach will not be considered further.

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#### **Combined Sewer Separation**

Sewer separation is the conversion of a CSS into a system of separate storm sewers and sanitary sewers. This can be accomplished by installing a new sanitary sewer and using the existing combined sewer as a storm sewer or vice versa. This practice can be very expensive, disruptive to the public, and difficult to implement, especially in downtown areas or other densely developed urban environments. It typically requires closure of public streets for construction while the new pipes are installed and the sewer is separated.

The City developed an Area Reduction Plan (ARP) in 2005 (latest revision in 2013), that provides a roadmap for sewer separation tied to re-development within the CSS. Although separation will likely be very costly and disruptive to the public, it is a primary technology that would completely eliminate CSOs. As such this option will be considered in greater detail as part of the alternatives evaluation.

### **3.3 Combined Sewer Optimization**

#### **Conveyance**

Conveyance is a technology that transports the combined sewage out of a particular area to a location where the flow can be stored, treated, or discharged where direct public contact with the water is less likely. Conveyance is accomplished by providing additional conveyance pipes or upsizing the existing conveyance pipe to a greater capacity. This practice can effectively reduce overflow volume and frequency in the affected areas. Large conveyance projects can be expensive and may require a lengthy permitting process. This is considered to be a primary technology for CSO control and will be considered in greater detail in the alternatives evaluation.

#### **Regulator Modifications**

A CSO regulator can be uniquely configured to control combined sewer overflow frequency and volume. The existing overflow control structures may be modified based on site-specific conditions - for example, by increasing the overflow weir height and length or raising the overflow pipe elevation. This technology is especially effective for CSO outfalls with high overflow frequency and low overflow volume, because the additional volume held back in the system is small and less likely to have negative impacts on upstream conditions. This is considered to be a primary technology for CSO control and will be considered in greater detail in the alternatives evaluation.

#### **Outfall Consolidation/Relocation**

Consolidation of one or multiple outfalls can help eliminate CSO discharges in sensitive areas. Outfall consolidation may require modification or relocation of an outfall, the installation of additional conveyance to accommodate new flow configurations, and may also require additional permitting with government agencies. This practice typically lowers O&M requirements for the CSS by limiting the number of outfall structures that need to be monitored. Outfall consolidation works best in areas where outfalls are located in close proximity to each other and require limited additional conveyance. This practice may be well suited for CSO-003 and CSO-004, which are separated by just over 300 feet.

Similar to regulator modifications, outfall consolidation is especially effective at reducing high frequency, low volume CSOs. This practice typically doesn't add a significant amount of extra capacity to the CSS

## CSO Control Technology Screening

### Section 3

(depending on the amount of conveyance pipe associated with the consolidation project), so its impact on infrequent, large volume CSO events can be limited. Modeling will need to be performed to determine the level of impact that outfall consolidation will have in terms of reducing the number of CSO events. Outfall consolidation and relocation is considered to be a primary technology for CSO control and will be considered in greater detail in the alternatives evaluation.

### **Real Time Control**

Real Time Control (RTC) is a highly automated system in which sewer level and flow data are measured at key points in the sewer system and used to operate systems controls to maximize the storage capacity of the CSS and limit overflows. The collected data is typically transferred to a control device where program logic is used to operate gates, pump stations, inflatable dams and other control components. Local dynamic controls are used to control regulators to prevent flooding and system wide dynamic controls are used to implement control objectives such as maximizing flow to the treatment plant or transferring flows from one portion of the CSS to another to fully utilize the system. Predicative control, which incorporates use of weather forecast data is an optional feature, but is complex and requires sophisticated operational capabilities.

It should be noted that RTC can only reduce CSO volumes where in-system storage capacity is available. Additionally this measure involves the installation of numerous mechanical controls which require upkeep and maintenance. Due to these limitations, this measure has been identified as a complementary technology. As such, it will be considered as part of the alternatives evaluation in combination with other primary technologies.

## **Section 4 Storage**

The objective of storage is to reduce overflows by capturing and storing wet weather flows in excess of CSS conveyance/ treatment plant capacity for controlled release back into the system for treatment after the storm event. A storage facility can attenuate peak flows in the CSS and provide a relatively constant flow into the treatment plant after peak events. Storage technologies do not prevent water from entering the CSS, but are very effective at reducing or eliminating CSO events. Storage technologies typically have fairly high construction and O&M costs compared to other CSO control technologies, but are a very reliable means of achieving CSO control goals.

### **4.1 Linear Storage**

Linear storage is provided by underground storage facilities that are sized to detain peak flows during wet weather events for controlled release back into the system after the event. In-line linear storages (storage in series with the CSS) can be provided by over-sizing the existing interceptors for conveyance, as described in the previous section, whereas off-line linear storage (storage parallel to the CSS) can be provided by installing new facilities such as tunnels and pipelines.

#### **Pipelines**

Large diameter parallel pipelines or conduits can provide significant storage in addition to the ability to convey flow. Pipelines are typically constructed between an overflow point and a pump station or treatment facility. The pipelines include discharge controls to allow flow to be stored within the pipeline during wet weather events, and slowly released by gravity following the event. Pipelines have the advantage of requiring a less area for construction compared to point storage. If trenchless technologies can be utilized, such as horizontal directional drilling (HDD), land requirements can be reduced even further.

One disadvantage of pipelines is that a larger volume is typically required to accommodate combined sewer storage needs. The installation of large diameter pipelines is typically less cost effective than tunneling, and the installation of smaller diameter pipes typically requires a significant length in order to provide adequate storage. Additionally, the installation of pipelines is very disruptive, typically requiring open trenches and the temporary closure of public streets. Due to the significant public disruption associated with this technology, it is not recommended and has been removed from further consideration.

#### **Tunnels**

Tunnels provide more storage volume than pipelines, while maintaining the ability to convey flow. Tunneling excavation is accomplished completely underground, and therefore results in minimal surface disruption and requires little right-of-way. Costs for tunnel storage is fairly reasonable compared to other storage technologies, depending on local geology. Tunnels are typically used in congested urban areas where available land is scarce. As such, it has been identified as a primary technology and will be considered in greater detail in the alternatives evaluation.

## CSO Control Technology Screening

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#### 4.2 Point Storage

Point storage can be provided by above-ground or underground storage facilities such as tanks and equalization basins. These off-line facilities are placed at specific points in the system to detain peak flows for controlled return back to the system.

##### **Tanks**

This technology reduces overflow quantity and frequency by storing all or a portion of diverted wet weather combined flows in off-line storage tanks. Stored flows are returned to the interceptor for conveyance to the treatment plant once system capacity becomes available. Storage tanks are generally fed by gravity and the stored flow is typically pumped back to the interceptor after the storm. The benefit of off-line storage tanks is that they are well suited for early action projects at critical CSO outfalls. Storage tanks capture the most concentrated first flush portion wet weather peak flow and help to reduce the downstream capacity needs for conveyance and treatment.

A disadvantage of off-line storage tanks is that they typically require large land area for installation, which may not be available in congested urban areas. Off-line storage tanks typically have higher costs per volume captured compared to other technologies. Additionally, if the existing sewers are deep, then the storage tank must also be deep, which results in additional construction costs. Operation and maintenance costs can also be high, especially if the application includes provisions for partial treatment and discharge, rather than simple storage and bleed-back to the sewer. Depending on the application, odor problems may also be an issue. However, storage tanks can be a very effective means of CSO control. As such, it has been identified as a primary technology and will be considered in greater detail in the alternatives evaluation.

##### **Wet Weather Storage Basin - AlexRenew**

The WRRF to which the City's CSS discharges is owned and operated by Alex Renew. Alex Renew currently has plans to install a Nutrient Management Facility (NMF) to manage influent loads on-site at the WRRF. While the NMF's primary function is to balance the nutrient loads, it may incidentally provide wet weather storage that may be used to increase the effective peak flow treatment of wet weather flows. CSO modeling under the LTCPU will incorporate the existing and expected capacity of the AlexRenew facilities. This will include working with AlexRenew to evaluate the extent to which the NMF facilities provide incidental wet weather management without impacting the principal function of nutrient management.

## Section 5 Treatment

Treatment technologies are intended to reduce the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the environment. Specific technologies can address different pollutant constituents, such as settleable solids, floatables, or bacteria. Where treatment facilities are to be considered, the LTCPU should contain provisions for the handling, treatment, and ultimate disposal of sludge and other treatment residuals.

### 5.1 CSO Facility

#### **Vortex Separators**

Vortex separation is a process that removes floatables and settleable solids from a wastewater stream by directing influent flow tangentially into a cylindrical tank, thereby creating a vortex. The vortex action causes settleable solids to move toward the center of the tank where they are concentrated with a fraction of the influent flow and directed to the underflow at the bottom of the tank. The underflow is then conveyed downstream to the treatment plant. The remaining influent flow travels under a baffle plate, which traps any floatables, and then over a circular baffle located in the center of the tank. It is then discharged to receiving waters or conveyed to storage or treatment devices for further processing. Since this technology does not address CSO volume or bacteria reduction, it would do little to meet the City's water quality and CSO control goals. This technology may be implemented as part of a treatment train with other technologies (e.g. disinfection, etc.), but will not be considered individually as viable option for the LTCPU.

#### **Screens and Trash Racks**

Screens and trash racks consist of a series of vertical and horizontal bars or wires that trap floatables while allowing water to pass through the openings between the bars or wires. They can be installed at select points within a CSS to capture floatables and prevent their discharge during CSO events. Due to limited hydraulic capacity, screens are most suitable for small outfalls. Trash racks or static screens can be located on top of an overflow weir or near the outfall. These devices are inexpensive but usually incur high maintenance costs due to their tendency to become clogged. Frequent cleaning (after every storm) is usually required to prevent clogging, which can cause serious flooding and sewer backups.

On the other hand, mechanical screens can remove floatables and some solids without frequent manual cleaning. This can be a significant advantage when compared to the maintenance requirements and the potential for flooding caused by a clogged static screen. However, most mechanical screens (climber screens, cog screens, or rake screens) require structural modifications to the outfall chamber to house and protect the screens. If weir-mounted mechanical screens are used instead, they require much less headroom and can be retrofitted into an existing overflow chamber with little to no structural modifications. The City has already installed static bar screens as CSO 002.

Since this technology does not address CSO volume or bacteria reduction, it would do little to meet the City's water quality and CSO control goals. Screens and trash racks may be implemented as part of a treatment train with other technologies (e.g. disinfection, etc.), but will not be considered individually as viable option for the LTCPU.

## CSO Control Technology Screening

### Section 5

#### **Netting**

Netting systems involve mesh nets that are attached to a CSO outfall to capture floatable material as the CSO discharges into the receiving water. The nets are nylon mesh bags that can be concealed inside the CSO outfall until an overflow occurs. The advantage of this technology is that it captures floatables inexpensively, and can provide a base level of control at some CSO sites. However the operation and maintenance cost is high and it has some negative aesthetic impacts associated with the visibility of collected trash in the waterbody. This technology is strictly for floatables control and will not address the City's water quality and CSO control goals. As such, it will not be considered further.

#### **Contaminant Booms**

A containment boom is a temporary floating barrier used to contain floatables entering into the waterway from a CSO outfall. Containment booms are used to reduce the spread of floatables and reduce the level of effort for post-storm cleanup. These devices are very simple to install, but can difficult to maintain. Also, there are some negative aesthetic impacts associated with visibility of collected trash in a waterbody. This technology is strictly for floatables control and will not address the City's water quality and CSO control goals. As such, it will not be considered further.

#### **Baffles**

Baffles are simple floatables control devices that are typically installed at flow regulators within the CSS. They consist of vertical steel plates or concrete beams that extend from the top of the sewer to just below the top of the regulating weir. During an overflow event, floatables are retained by the baffles while water passes under the baffles, over the regulator, and into the receiving water body. When the flow recedes below the bottom of the baffle, floatable material is carried downstream to the treatment plant. Baffles are easy to install and require little maintenance, but do require proper hydraulic configuration. This technology is strictly for floatables control and will not address the City's water quality and CSO control goals. As such, it will not be considered further.

#### **Disinfection**

This technology consists of disinfecting sewer overflows at a local facility near the CSO outfall. Disinfection is very effective at reducing bacteria through inactivation, but provides only limited opportunities for volume reduction. It provides limited reductions in TSS, floatables, and nutrient loads, unless other processes (e.g. screening, high-rate clarification, etc.) are provided upstream of the disinfection facility. Disinfection of wet weather flow is more challenging to design and control than traditional disinfection at a treatment plant, because of the complex characteristics of the flow. Intermittent occurrence and highly variable flowrate make it more challenging to regulate the addition of disinfectant. One way to address the variable flow issue is to provide flow retention facilities that provide for disinfectant contact time and capture through storage the first flush of TSS, floatables and nutrients.

Wet weather flows can vary widely in temperature, suspended solids concentrations, and bacterial composition. Therefore, pilot studies are usually needed to characterize the range of conditions that exist for a particular area and the design criteria that need to be considered. Experience has shown that the long contact time required for conventional wastewater treatment is not appropriate for the treatment of wet weather flows. Disinfection can be achieved by providing an increased disinfection dosage and intense mixing to ensure disinfectant contact with the maximum number of microorganisms.



## CSO Control Technology Screening

### Section 5

Various disinfection technologies are available, both with and without chlorine compounds. In addition to disinfection effectiveness, many factors should be considered when selecting a disinfectant, including potential toxic effects to the environment, regulations for residuals, safety precautions, and ease of operation and maintenance. Ultraviolet (UV) and peracetic acid (PAA) are two alternatives to chlorine compounds for wet weather disinfection.

- The main advantages of UV include its ability to quickly respond to flow variation and the absence of a disinfectant residual, among others. The size of the UV system mainly depends on the UV transmittance (i.e. the ability of wastewater to transmit UV light) and TSS concentrations in the wastewater. One of the challenges for UV disinfection is determining how to manage the disinfection of effluent during a power outage. In addition, UV typically has higher capital cost compared to chlorine disinfection systems.
- The main advantage of peracetic acid over sodium hypochlorite is its long “shelf life” without product deterioration. Due to the intermittent nature of CSO flows, stored sodium hypochlorite may degrade over time if not used. However, PAA systems generally have higher operating costs than chlorine systems.

Disinfection has been identified as a primary technology and will be considered in greater detail in the alternatives evaluation.

### **High Rate Physical/Chemical Treatment (ActiFlo®)**

High rate physical/chemical processes, such as Veolia’s Actiflo® or Infilco-Degremont’s DENSADeg®, are treatment facilities that require a much smaller footprint than conventional processes. These two competing products have very similar applications, but have processes that differ from each other considerably. For brevity, only one of these processes (Actiflo®) is described in detail below.

Fundamentally, the Actiflo® process is very similar to conventional coagulation, flocculation, and sedimentation water treatment technology. Both processes use coagulant for suspended solid destabilization and flocculent aid (polymer) for the aggregation of suspended materials. The primary difference between Actiflo® and conventional processes is the addition of microsand for the formation of high-density flocs that have a higher-density nucleus and thus settle more rapidly.

Clarified water exits the process by flowing over a weir in the settling tank. The sand and sludge mixture that remains is collected at the bottom of the settling tank and pumped to a hydrocyclone which separates the sludge from the microsand. Sludge is discharged out of the top of the hydrocyclone while the sand is recycled back into the Actiflo® process for further use. This process requires upstream screening to ensure that particles larger than 3 to 6 mm do not clog the hydrocyclone.

Actiflo® performance varies, but in general removal rates of 80 - 95% for TSS and 30 - 60% for BOD are typical. Phosphorous and nitrogen are also removable with this process, although the removal efficiencies are dependent on the solubility of these compounds present in the wastewater. Phosphorous removal is typically between 60 – 90%, and nitrogen removal is typically between 15 – 35%. Removal efficiencies are also dependent on start-up time. Typically the Actiflo® process takes about 15 minutes before optimum removal rates are achieved.



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As previously stated, the LTCPU primary goals are bacteria reduction and CSO volume reduction. While high rate physical/chemical treatment reduces bacteria somewhat, its principal purpose is TSS reduction. Disinfection would be required downstream for bacteria inactivation. Additionally, while disinfection can be enhanced with upstream treatment, it can be adequately accomplished without high rate physical/chemical treatment. As such, these processes do not add significant value compared to disinfection alone. Furthermore, while technologies such as Actiflo<sup>®</sup> or DENSADEG<sup>®</sup> reduce the footprint of conventional treatment, they still require a significant amount of available space for implementation. As such, this technology has been removed from further evaluation.

#### **High Rate Physical Treatment (Fuzzy Filters)**

The Fuzzy Filter<sup>®</sup> by Schreiber or the WesTech WWETCO FlexFilter<sup>™</sup> is an innovative filtration technology that used a compressible filter media that allows for a much smaller footprint than conventional filtration (footprint reductions of nearly 90%). Both technologies use a synthetic fiber media, as opposed to granular media such as sand, which can handle increased flux rates (up to 30 – 40 gpm/sf). Additionally, the process uses compressed air scour with influent flow for filter backwashing which eliminates the need for storage tanks. The filter removes up to 80% of influent particles up to 4 microns in diameter. Overall, this is a relatively low maintenance process, which requires periodic lubrication and detergent addition for media washing.

This technology is designed for TSS reduction and does not address the primary goals of the City's LTCPU (bacteria reduction and overflow volume reduction). Since downstream disinfection would be required for bacteria inactivation, this technology provides little benefit compared to disinfection alone. Additionally, although this technology decreases the footprint of conventional filtration, it still requires a substantial footprint for implementation. As such, this process has been removed from further consideration.

## 5.2 Water Resources Recovery Facility (WRRF)

#### **Additional Treatment Capacity - AlexRenew WRRF**

CSOs can potentially be reduced by increasing the treatment capacity of the WRRF. Plans are currently being evaluated to increase the capacity of AlexRenew's WRRF from a peak capacity of 108 mgd to 116 mgd in conjunction with the additional WRRF storage capacity described previously. The City's CSS has sufficient conveyance capacity to deliver this much flow to the plant. However, the current plans for additional treatment and storage capacity at the WRRF provide a limited increase in capacity that is not sufficient to meet the City's water quality and CSO control goals. Treatment capacity for additional flows, beyond what is currently being considered, would be very expensive, require land that is not currently available at the WRRF, and would require additional conveyance in the CSS. Since additional conveyance would be needed to accommodate these additional flows, it would likely be more cost effective to increase the storage capacity of the CSS (e.g. tunnel, pipeline, etc.) than to convey the full peak flow to the WRRF for treatment. As such, this option is not recommended and has been removed from further consideration.

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#### **Wet Weather Blending - Alex Renew WRRF**

Blending is the practice of allowing portions of the wet weather peak flow to bypass certain treatment facilities at the WRRF. In blending, wet weather flows are typically routed through primary treatment, allowed to bypass secondary and tertiary treatment, and then recombined with effluent from all processes prior to disinfection and discharge to the environment. This practice may require increasing the capacity of primary treatment and disinfection facilities, but doesn't require the upsizing of secondary treatment facilities, which can be the more costly components.

Blending would require expansion of the influent pumping, primary treatment and disinfection unit processes at Alex Renew. As previously discussed, primary treatment is not required to meet the City's primary LTCPU goals (bacteria and overflow volume reduction). Although wet weather blending would decrease TSS loads to the receiving water, this technology does no more to meet primary LTCPU goals than disinfection at the CSO outfall, and would be considerably more expensive. As such, blending adds little benefit compared to disinfection alone (which will be evaluated). In addition, all the land on the Alex Renew site is committed to existing and future treatment needs, so it would be very difficult (if not impossible) to site additional primary treatment units. As such, this option is not recommended and has been removed from further consideration.

## Section 6 Green Infrastructure

Green infrastructure (GI) is a source control that reduces runoff volumes, peak flows, and/or pollutant loads. GI utilizes the processes of infiltration, evapotranspiration, and capture for re-use to reduce the amount of runoff volume (USEPA, 2014). It is effective at increasing the time of concentration of remaining runoff and reducing pollutant loads through sedimentation and filtration. This technology can be used alone in a scalable manner, or it can be used in conjunction with gray infrastructure to reduce the size and costs of gray infrastructure.

GI's benefits extend beyond reducing the flow of water into CSSs during wet weather events. Through mimicking a more naturalized system, GI can deliver a broad range of ecosystem services or benefits to people, some of which include: improved community livability (aesthetics and property values), human health, air quality, water quality, groundwater recharge, wildlife habitats and connectivity; reduced heat island effects; reduced energy use; green jobs; and recreational opportunities (US EPA, 2014). It can also help reduce flooding and is flexible for addressing climate change (droughts or increased precipitation).

As described in *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control* (EPA, March 2014), the EPA requires that any incorporation of GI into a LTCP include analysis in two areas:

1. Community and political support for GI; and
2. Realistic potential for GI implementation.

The City will assess the public support from stakeholders in the community and government for the GI alternatives through the implementation of the LTCPU Public Participation Plan. The realistic potential for the implementation will first be screened within this memorandum and refined further in the alternatives evaluation.

There are a wide range of potential GI technologies currently in use throughout the country, and many of these include numerous design variations incorporated into a variety of documents and design manuals. The intent of this section is to summarize important aspects of the relevant practices, rather than to provide a comprehensive catalog or detailed design documents. These recommendations were coordinated with the VA SWM BMP Clearinghouse and the City of Alexandria's Green Sidewalks BMP Design Guidelines.

In addition, there are watershed-scale GI options that are not appropriate for the City due to the relatively small size and highly urbanized nature of the CSS area. These include land conservation efforts and creation, preservation, or restoration of riparian buffers, flood plains, wetlands, open space, and forests. These are not considered feasible for the City and will not be considered further.

With the above considerations in mind, feasible and appropriate GI technologies were evaluated for implementation in the following areas for City owned property:

- Buildings
- Impervious Areas
- Pervious Areas

## CSO Control Technology Screening

### Section 6

#### 6.1 Requirements

The City's VPDES Permit (VA0087068) for the Combined Sewer System includes the following requirements related to GI.

- **Green Initiative:** *The permittee shall study, implement and promote green infrastructure projects within the CSS sewershed during this permit term. Projects evaluated shall include, but are not limited to: rainfall harvesting, permeable pavements, rain gardens, green roof installation, bioretention cells, urban forestation/reforestation and public education.*
- **Green Public Facilities:** *The permittee shall evaluate the practicality of incorporating green infrastructure during major maintenance/enhancement projects at all city facilities (offices, schools, libraries etc) located within the CSS sewershed. The permittee shall include with the annual reports, commencing with the report for 2014: (1) a schedule of maintenance/enhancement projects at city facilities within the CSS sewershed for the forthcoming fiscal year; (2) the City's process for evaluating inclusion of green infrastructure; and (3) green infrastructures planned for selected projects. Technologies to be considered shall, at a minimum, include those listed under the aforementioned Green Initiative Special Condition. Maintenance/enhancement projects for historic designated facilities/structures are exempt from this Special Condition.*
- **Green Maintenance:** *The permittee shall establish, or alternatively incorporate, a database to manage information on all green infrastructure practices put in place that are owned and/or maintained by the City. The database shall schedule and track maintenance activities to ensure infrastructures are maintained for proper performance. The permittee shall submit to DEQ two updates on the status of the database development. The first update shall be provided on or before 23 August 2014 and the second on or before 23 August 2015. On or before 23 August 2016, the permittee shall submit to DEQ a final report detailing the full database development and implementation.*

It is important to note that these permit requirements are not explicitly required under the LTCPU; however, there are opportunities for synergies with the LTCPU where appropriate.

Use of green infrastructure provides an opportunity to collaborate across City departments and with external groups. Collaboration across departments is necessary to address all policies and requirements for infrastructure impacting or abutting the green infrastructure features (roads, sidewalks, parks, buildings, etc.). It also allows for sharing of department expertise to improve the assets and gain support for the assets, including the future operations and maintenance responsibilities.

The use of green infrastructure as part of the City's LTCPU also addresses nine of the eleven items listed in the vision of the EcoCity Charter and seven of the nine items in the Environmental Action Plan 2030 (transportation and solid waste are not directly addressed). In addition, the City's citizen education and support services in the "Build Your Own Rain Barrel Workshops" promote green infrastructure at the homeowner scale. The City's Green Sidewalks BMP Design Guidelines provides specific instructions for provided stormwater best management practices in the City's Public rights-of-way.

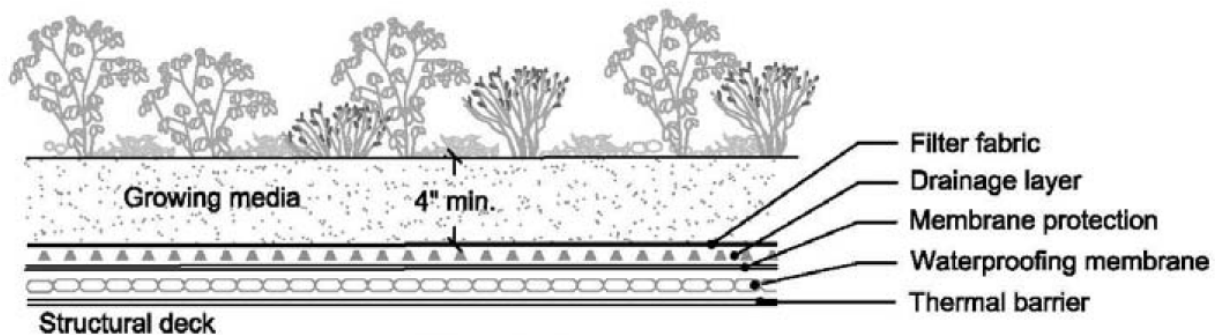
## 6.2 Buildings

### **Green Roofs**

Green roofs have bioretention media that collect runoff to promote infiltration and evapotranspiration. They are typically shallow in depth (4-8") based on the ability of the building to support the weight of the media, plantings, and captured rainfall. Green roofs may be built in layers on a roof or installed as cells in crates.

Green roofs are recommended for use on buildings with flat roofs (recommended 1-2% slope) that have the structural capacity to support the weight of the media, plantings, and water. Structural improvements to an existing building to support the additional weight associated with a green roof are not typically recommended; therefore this technology is more feasible on new construction. Green roofs can be installed in a section or across an entire roof. An overflow system is typically installed. The vegetation may require irrigation during the first 1-2 years to establish growth. Recommended maintenance for green roofs includes semi-annual maintenance of vegetation.

**Figure 6-1**  
**Example Green Roof Section**



Many rooftop retrofits are required for this GI technology to have measureable impact. Currently, more than 97% of the buildings in the CSS are privately owned. Implementing this technology on a scale that would have a measureable impact would require retrofits on private property, which would be very difficult for the City to require. Although green roofs have many benefits, due to the limitations stated above, this GI practice is not likely to be a significant component of the LTCPU and will not be considered further.

### **Blue Roofs**

Blue roofs have media that collect runoff to promote infiltration and evaporation (they do not have plantings). They are typically shallow in depth (4-8") based on the ability of the building to support the weight of the media and captured rainfall. Blue roofs may be built in layers on a roof or installed as cells in crates.

## CSO Control Technology Screening

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Blue roofs are recommended for use on buildings with flat roofs (recommended 1-2% slope) that have the structural capacity to support the weight of the media and water. Structural improvements to an existing building to support the additional weight associated with a green roof are not typically recommended; therefore this technology is more feasible on new construction. Blue roofs can be installed in a section or across an entire roof. An overflow system is typically installed. Recommended maintenance for blue roofs includes semi-annual maintenance for clearing of debris.

Similar to green roofs, blue roofs would require implementation on private property to have a measureable impact. It is unlikely that the City would be able to require roof retrofits on private property. Although blue roofs have many benefits, due to the limitations stated above, this GI practice is not likely to be a significant component of the LTCPU and will not be considered further.

### **Rainwater Harvesting**

Rainwater harvesting is the collection and storage of rainfall from buildings to delay or eliminate runoff. The reduction in runoff volume varies based on the size of the storage unit (rain barrel or cistern) and the reuse of the stored rainfall. Typical reuse options are irrigation and vehicle washing. Indoor reuse options, such as toilet flushing and heating and cooling, may be possible if coordinated with building policies.

Rainwater harvesting is applicable to all types of buildings with gutters and downspouts but may be reserved for buildings where green or blue roofs are not appropriate (roof slopes greater than 2%). Storage units may be sized and installed for each downspout or for the building as a whole. Rain barrels are typically used for residential installations and larger cisterns are typically used for non-residential applications. They are typically placed at grade but can be buried below grade if a pumping system for water reuse is provided. An overflow system is typically installed. Recommended maintenance for rainwater harvesting includes semi-annual maintenance for clearing of debris in the piping or storage unit.



## CSO Control Technology Screening

### Section 6

**Figure 6-2**  
**Rain Barrels**



Similar to green roofs and blue roofs, this technology is limited by the number of available roofs, most of which are private. However, the City has seen some private use of rain barrels and encourages collection of rooftop runoff through “*Build Your Own Rain Barrel Workshops*”. Private uses of cisterns are much less common. Due to the limitations associated with this technology it is not likely to be a significant component of the LTCPU and has been removed from further consideration.

### 6.3 Impervious Area

#### Permeable Pavements

Permeable pavements promote runoff infiltration and rely on a permeable substrate (engineered soils) to store runoff and remove pollutants. There are several types of permeable pavements: asphalt, concrete, and pavers. Permeable asphalt and concrete are similar to traditional mixes except that the amount of fine aggregates is reduced or eliminated. Permeable pavers are individual paver units laid together to create a paved surface. The depth of the permeable substrate, anywhere from 3-10 feet, will have the largest impact on runoff volume reduction. Substrate design may incorporate stormwater retention chambers to increase storage volume. Underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation.

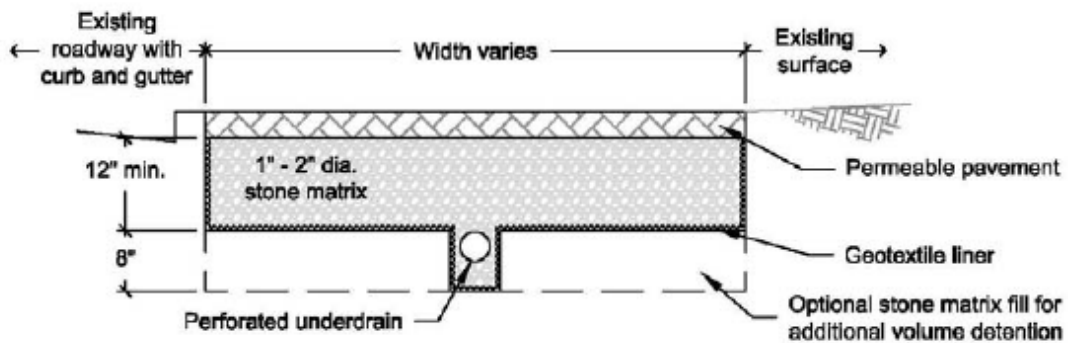
Permeable pavements are recommended for low traffic and low speed traffic areas such as sidewalks, parking lanes, parking lots, driveways, and alleys. Recommended maintenance for permeable pavement

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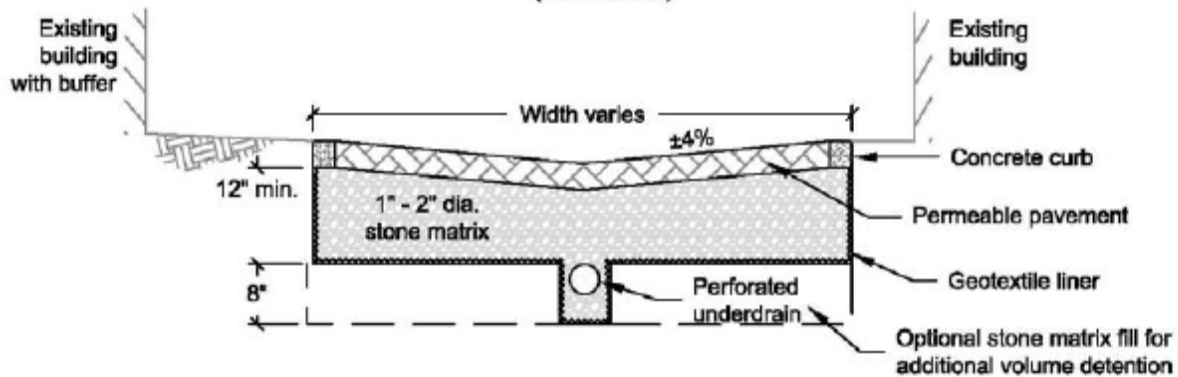
### Section 6

includes semi-annual inspections and vacuuming. Preventative maintenance is also necessary to minimize the introduction of soil and other fine particles that could clog the pavement pores.

**Figure 6-3**  
**Example Permeable Sidewalk Section**



**Figure 6-4**  
**Example Permeable Alley Section**

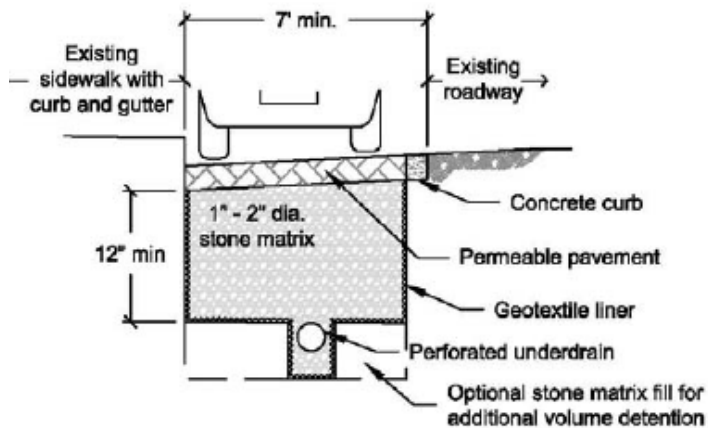




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**Figure 6-5**  
**Example Permeable Parking Lane Section**



**Notes:**

1. Depth of stone matrix will be determined by structural requirements, storage desired, and permeable pavement type.
2. Top of existing sewer and other utilities shall be a minimum of 1' below the invert of the stone matrix.
3. All underdrains will connect to the existing storm sewer system via solid pipe.

This GI technology can be very effective when implemented in parking lots, parking lanes, and narrow sidewalks where planter boxes cannot be implemented. As such, it has been recommended for further consideration in the alternatives evaluation.

### **Planter Boxes**

Planter boxes are bioretention cells that collect runoff and promote runoff infiltration. These walled units are similar to free-form rain gardens as vegetated depressions (12-24") that rely on ponding and a permeable substrate (engineered soils) to store runoff and remove pollutants. There are two primary sizes of planter boxes for use based on the drainage pattern in developed areas: sidewalk planter boxes and bumpout planter boxes. In the City's Green Sidewalks BMP Design Guidelines, sidewalk planter boxes are more specifically referred to as a Tree Well BMP, a Tree Well with Soil Panels, a Continuous Planting Strip, Mid-Sidewalk BMP, and Back of Sidewalk BMP.

The depth of the permeable substrate, anywhere from 3-10 feet, will have the largest impact on runoff volume reduction. Substrate design may incorporate stormwater retention chambers to increase storage volume. Properly designed planter boxes limit ponding to 3-6 hours after a storm. Ponding overflow pipes and/or underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation. The vegetation promotes evapotranspiration to reduce the volume of the stored runoff.

Planter boxes are recommended for use in regularly spaced intervals in the downstream drainage path in areas of impervious cover. Sidewalk planter boxes are depressed below the elevation of the existing sidewalk. Bumpout planter boxes are larger units that bumpout the sidewalk curb into an area of a parking lane. Curb cuts allow roadway runoff to enter the cells and overflow once the maximum ponding depth has been reached.

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Recommended maintenance for planter boxes includes semi-annual inspections and improvements to vegetation and mulch and annual inspection of overflow pipes and underdrains, if applicable. Annual inspection after a large storm is also recommended; if there is evidence of ponding after 48 hours, mulch replacement or overflow pipe cleaning may be necessary.

Planter boxes are well suited for highly developed areas where space allows. They can be installed block-by-block to contain, infiltrate, and evapotranspire stormwater runoff. As such, the GI technology has been recommended for further consideration in the alternatives evaluation.

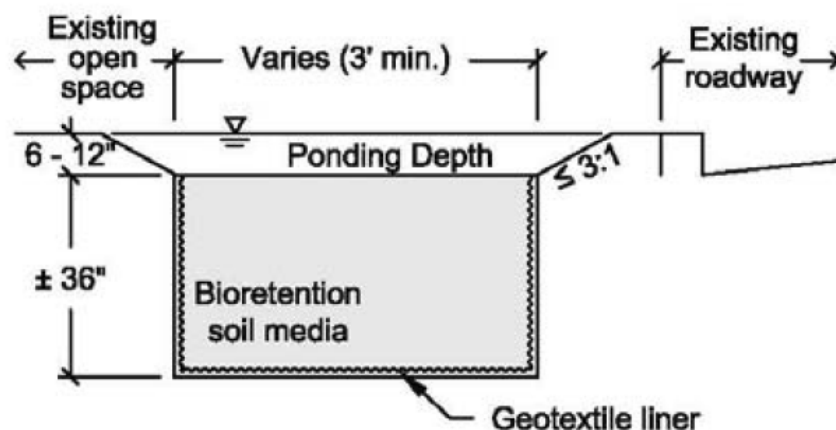
#### 6.4 Pervious Area

##### Bioswales

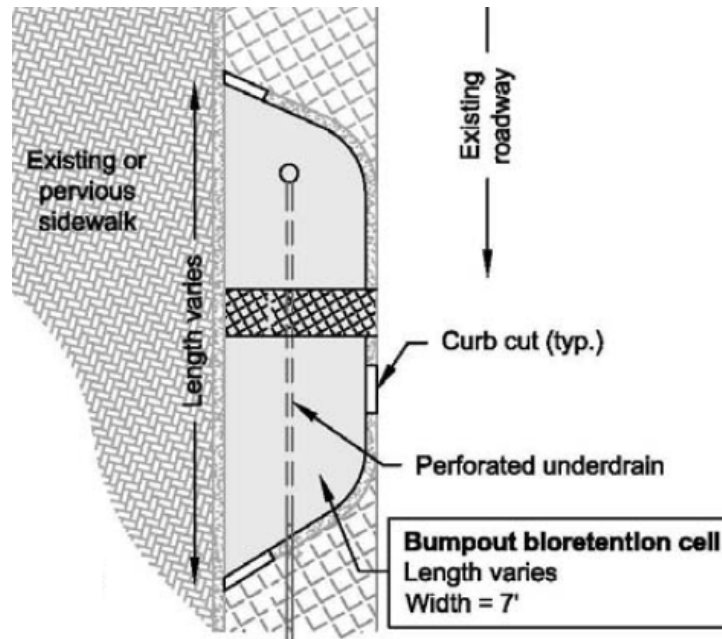
Bioswales are vegetated channels that reduce runoff velocity and promote runoff infiltration. These are linear channels with shallow depressions (6-12") that incorporate vegetation and a permeable substrate (engineered soils). As a channel, runoff not infiltrated does not pond but flows through the swale and runs off back into the surrounding environment. The channels, especially those with slopes greater than 6%, may incorporate check dams to assist in reducing runoff velocity and promote infiltration and pollutant removal.

Bioswales are recommended for use in parks and areas of natural cover since they primarily reduce runoff velocity and have a low volume reduction per square foot. Due to their linear nature, bioswales may also be effective in the buffer between open space areas and impervious areas with high volumes of runoff such as roads and parking lots. Recommended maintenance for bioswales includes semi-annual inspections and improvements to vegetation and mulch.

**Figure 6-6**  
**Example Bioswale Detail**



**Figure 6-7**  
**Example Bumpout Planter Box Section**



This technology incorporates both stormwater treatment and stormwater conveyance. While not as flexible as planter boxes, there may be locations in the City CSS where a bioswale could be effective. Thus the GI technology has been recommended for further consideration in the alternatives evaluation where planter boxes are first shown to have potential for application.

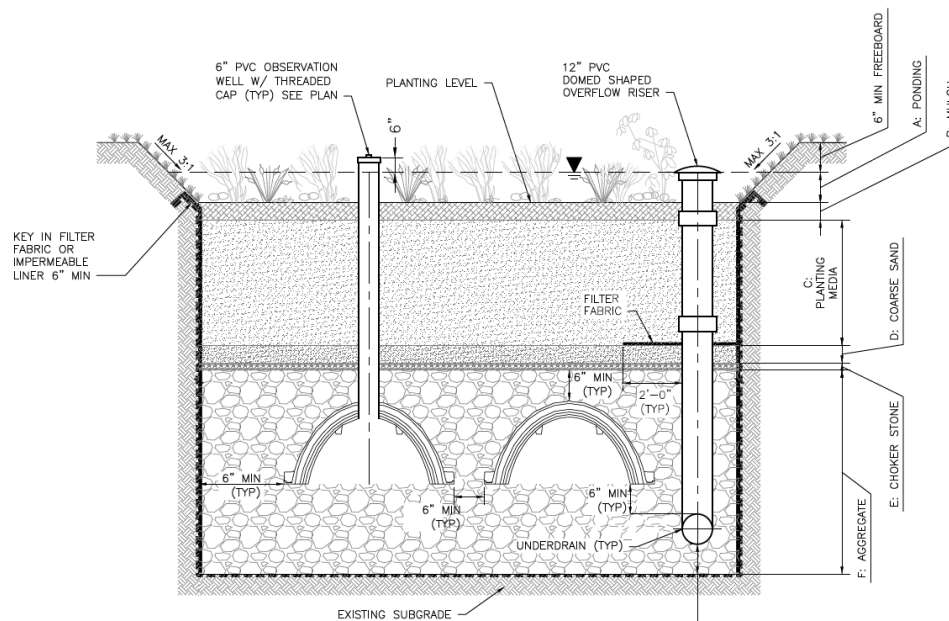
### **Free-Form Rain Gardens**

Rain gardens are bioretention basins that collect runoff and promote runoff infiltration. These are vegetated depressions (12-24") that rely on ponding and a permeable substrate (engineered soils) to store runoff and remove pollutants. The size and shape of rain gardens can be tailored to site-specific needs; however, the depth of the permeable substrate, anywhere from 3-10 feet, will have the largest impact on runoff volume reduction. Substrate design may incorporate stormwater retention chambers to increase storage volume. Properly designed rain gardens limit ponding to 3-6 hours after a storm. Ponding overflow pipes and/or underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation. The vegetation promotes evapotranspiration to reduce the volume of the stored runoff.

Rain gardens are recommended for use in low points in parks and areas of natural cover so they can blend in seamlessly with a grassed buffer and enhance the vegetation without appearing to be a stormwater control mechanism. Locations near the transition from pervious to impervious cover can provide runoff reduction for nearby impervious areas.

Recommended maintenance for rain gardens includes semi-annual inspections and improvements to vegetation and mulch and annual inspection of overflow pipes and underdrains, if applicable. Annual inspection after a large storm is also recommended; if there is evidence of ponding after 48 hours, mulch replacement or overflow pipe cleaning may be necessary.

**Figure 6-8**  
**Example Rain Garden Section**



Rain gardens are very effective at capturing and treating stormwater and have versatile footprints that make them advantageous for use in highly developed urban environments, such as the City's CSS area. As such, it has been recommended for further consideration in the alternatives evaluation.

## 6.5 Summary

A summary of the above green infrastructure items is provided in Table 6-1 below. The table includes the area served, estimated volume of stormwater controlled during a 1" storm, appropriate location, and maintenance required for each item according to the VA SWM BMP Clearinghouse.

## CSO Control Technology Screening

### Section 6

**Table 6-1**  
**Summary of GI Options**

GI Item	Area Served	Estimated Controlled Stormwater Volume for 1" Storm	Location	Maintenance Required
Green Roofs	Installed area	45-60% reduction	Buildings	Semi-annual vegetation maintenance; annual cleaning of pipes
Blue Roofs	Installed area	45-80% reduction	Buildings	Semi-annual debris maintenance; annual cleaning of pipes
Rainwater Harvesting	Roof drainage area	Up to 90% reduction	Buildings	Semi-annual debris maintenance; annual cleaning of pipes
Permeable Pavements	2 to 4 x Installed area	45-75% reduction	Sidewalks, parking lanes, parking lots, driveways, and alleys	Semi-annual vacuuming; preventative measures against fine aggregates
Planter Boxes	10 to 20 x Installed area	40-80% reduction	Sidewalks and parking lanes	Semi-annual vegetation and mulch maintenance; annual cleaning of overflow pipes and underdrains
Bioswales	10 to 20 x Installed area	10-60% reduction	Open Space	Semi-annual vegetation and mulch maintenance
Free-form Rain Gardens	10 to 20 x Installed area	40-80% reduction	Open Space	Semi-annual vegetation and mulch maintenance; annual cleaning of overflow pipes and underdrains

Based upon a consideration of the benefits and limitations of each of the GI technologies discussed in this memorandum, the following technologies have been identified for further consideration in the alternatives evaluation:

- Permeable Pavement
- Planter Boxes
- Bioswales
- Rain Gardens

## CSO Control Technology Screening

### Section 7

## Section 7 Recommend Alternatives for Evaluation

Based on the above, Table 7-1 summarizes the alternatives and associated technologies that are recommended for the more detailed evaluation in the Alternatives Evaluation phase of the LTCPU. Additional combinations may be considered as the detailed evaluations progress.

**Table 7-1  
Summary of Alternatives**

No.	Description	Technologies
1.	Tunnels from CSO 003/004 and CSO 002 to AlexRenew	Storage, Outfall Consolidation, Regulator Modifications, and Real Time Control
2.	Tunnel to the Potomac River capturing CSO 002, 003, and 004.	Storage, Conveyance, Outfall Relocation, Regulator Modifications, and Real Time Control
3.	Storage at CSO 003/004 and CSO 002	Above Ground Storage, Below Ground Storage, and Regulator Modifications
4.	Disinfection	UV, Peracetic Acid, and Sodium Hypochlorite Disinfection
5.	Separation	Rain Leader Disconnection, Sump Pump Disconnection, Sewer Separation
6.	Green Infrastructure	Permeable Pavement, Planter Boxes, Bioswales, and Rain Gardens
7.	Tunnel from 003/004 to AlexRenew + Storage at 002	Storage, Outfall Consolidation, Regulator Modifications, and Real Time Control
8.	Tunnel form 003/004 to AlexRenew + Disinfection at 002	Storage, Outfall Consolidation, Regulator Modifications, Disinfection, and Real Time Control
9.	Tunnels from 003/004 and 002 + GI and Separation	Storage, Outfall Consolidation, Regulator Modifications, GI, and Separation, and Real Time Control
10.	Tunnel from 003/004 to AlexRenew + Storage at 002 + GI and Separation	Storage, Outfall Consolidation, Regulator Modifications, GI, and Separation, and Real Time Control

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